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Short report

Estimation of postmortem time based on aorta narrowing in CT imaging

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ABSTRACT

Computed tomography (CT) in forensic medicine is commonly used in determination of cause of death. Here, we show that the information provided by CT may also be of value for estimation of time after death. The relationship between abdominal aorta narrowing just below the diaphragm and time after death was examined in 140 cases. Aorta narrowing was defined using a flatness ratio, which was calculated by dividing the shorter axis of the aorta by the longer axis. Time after death was classified into 6 time periods. The flatness ratio gradually and significantly decreased with increased postmortem time, showing increased aorta narrowing with increased time after death. A further examination of aorta narrowing in 15 autopsy cases in which CT images were taken at two postmortem times gave similar findings. The results of the study suggest that aorta narrowing in postmortem CT imaging may be used to estimate time after death.

1. Introduction

Indices such as body temperature and rigor mortis are used for estimation of time of death, but these methods are not always sensitive and are influenced by factors such as the environment in which the body is found, body mass, clothing, and cause of death. Thus, estimation of time of death may be incorrect. For this reason, development of more precise methods of estimation of time of death is required.

CT imaging for diagnosis of cause of death is increasingly widely used globally.[1–5] CT imaging is advantageous because it produces intracorporeal information in a non-invasive manner. We have used a CT scanner for three years prior to autopsy for determination of pathological changes and preservation of data. Collapse of the abdominal aorta is noticeable on CT images in many postmortem cases and we suspected a relationship between the aorta flatness and postmortem time. However, this relationship has not been examined, despite the common use of CT imaging in autopsy cases.

In this study, we investigated the relationship between postmortem time and aorta flatness in 140 cases and examined the change of the aorta shape with postmortem time in 15 cases in which CT images were taken twice at different postmortem times. Based on these data, we examined if aorta narrowing is related to time after death.

2. Materials & methods

The relationship between aorta narrowing and time after death was examined using CT images taken within 5 days of death in 140 cases for which the postmortem time was known (Table 1). We limited the analysis to cases within 5 days postmortem time because complete aortic collapse was observed in almost all cases after 5 days. Most of the cases were discovered in the supine position and placed in the supine position until CT images were taken. The 140 cases had various causes of death. As a result of victims of fire often being found in what looks like a fighting stance, referred to as boxer's attitude, not being able to pass throughout a CT scanner.

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Table 1
Classification of time after death for 140 cases in the study.

Time after death	Number of cases	Age (average)
12 h	20	70.6
24 h	32	65.1
48 h	57	64.1
3 days	12	70.0
4 days	10	67.6
5 days	9	64.0
Total	140	66.9

CT imaging was performed with an ECLOS-4 scanner (Hitachi Medical Co., Tokyo) with a 16 × 2.5 mm slice thickness whole body scan. Aorta axis data were collected and averaged from 3 images taken at 2.5-mm intervals from three locations: the thoracic aorta, the abdominal aorta just below the diaphragm, and the lower abdominal aorta where it splits to form the common iliac artery (Fig. 1). This analysis was performed using the Hyper Q-Net CT image analysis system (Hitachi Medical Co., Tokyo). The degree of aorta narrowing was defined as the average flatness ratio from the three images. This ratio was calculated by dividing the shorter axis of the aorta by the longer axis (Fig. 1). Aorta narrowing was examined in cases classified into six categories within 12 h, 24 h, 48 h, 3 days, 4 days, and 5 days after death.

To investigate aorta narrowing over time in individual autopsy cases, CT imaging was conducted twice in 15 cases at average times of 26 h and 56 h after death, respectively, and the aorta flatness ratio was compared.

3. Results

The results of the first part of the study are shown in Fig. 2. The *Y*-axis shows the flatness ratio, with 1.00 representing a circular cylinder and 0.00 a flat cylinder. The average flatness ratios for narrowing of the abdominal aorta just below the diaphragm were 0.76 ± 0.12, 0.64 ± 0.15, 0.51 ± 0.17, 0.43 ± 0.11, 0.38 ± 0.06, and 0.33 ± 0.07 in CT images taken within 12 h, 24 h, 48 h, 3 days, 4 days, and 5 days postmortem, respectively (Fig. 2). These data show significant narrowing of the abdominal aorta just below the diaphragm with increased postmortem time ($P < 0.01$). In contrast, there was no significant difference in the shape of the thoracic aorta and lower abdominal aorta among the 6 time periods. There were no significant differences among the various causes of death.

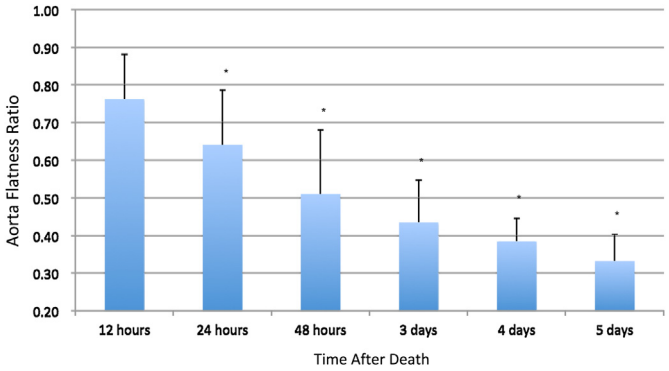

Fig. 2. Comparison of time after death and aorta narrowing just below the diaphragm. Aorta narrowing gradually increased (as shown by the decrease in the flatness ratio) with increased time after death. $p < 0.01$ vs. 12 h ($n = 140$).

The average aorta flatness ratios in cases in which CT was conducted twice were 0.61 ± 0.14 and 0.45 ± 0.13 after mean periods of 26 h and 56 h, respectively (Fig. 3), with a significant difference in aorta narrowing between the time periods ($P < 0.01$). Measurements in these cases were only performed for the abdominal aorta just below the diaphragm.

4. Discussion

The results of the study show that there is a relationship between aorta narrowing and postmortem time. The mechanism of aorta narrowing is probably the result of gravity. In contrast, the absence of significant narrowing of the thoracic aorta and lower abdominal aorta where it splits to form the common iliac artery over postmortem time is believed to be due to the anatomy of thorax and to atherosclerosis, respectively. The thorax supports and protects the thoracic aorta and prevents narrowing, while the bifurcating flow caused by splitting of the aorta to form the common iliac artery promotes atherosclerosis[6] that inhibits narrowing

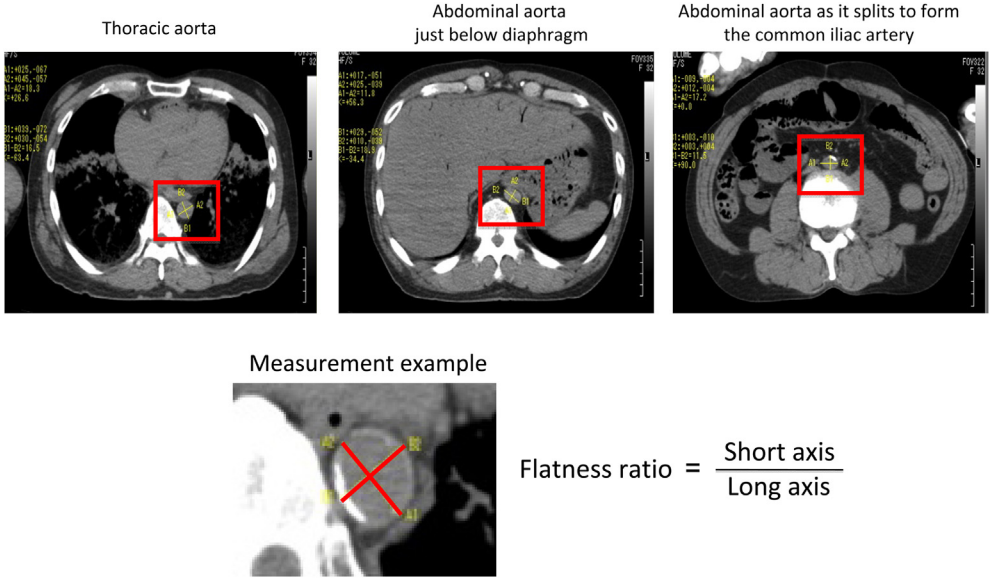

Fig. 1. Three locations at which the aorta flatness was measured (upper panel) and the method of measurement of the flatness ratio (lower panel).

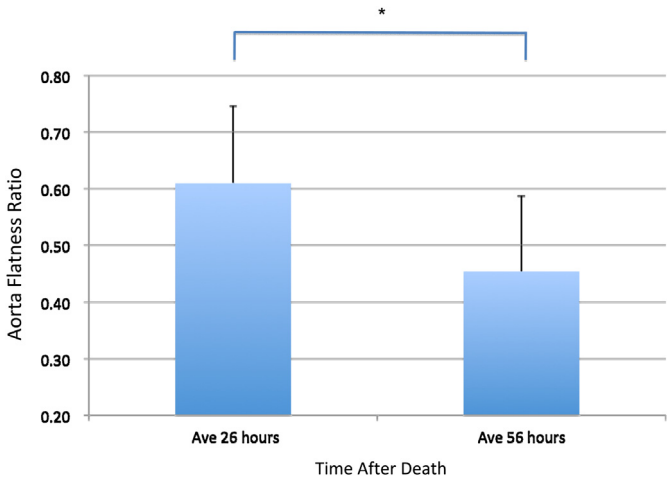

Fig. 3. Comparison of abdominal aorta narrowing just below the diaphragm measured at two time points in 15 cases. The flatness ratio decreased significantly at the later time point ($p < 0.01$), indicating increased aorta narrowing.

of this section of the aorta, despite the absence of supporting bone structures. In the exsanguination cases, it is expected that the aorta narrowing can be seen in the early stage. However, there were two cases which cause of death was exsanguination in our study, but their narrowing rates were almost the same as mean value in each group. There were five cases of hemorrhagic shock but their narrowing rates were relatively higher than the mean value. As a result of the small number of the exsanguination cases and hemorrhagic shock cases, we cannot draw immediate conclusions. However, we have to say that there are no differences among the cause of death in our study.

The significant difference in aorta narrowing just below diaphragm among the six postmortem periods suggests that estimation of time of death may be possible using CT images. However, accurate establishment of time after death using this method will require a more detailed investigation of factors that may influence aorta narrowing, including degree of decomposition, influence of cardiopulmonary resuscitation, and posture and build of the deceased. With consideration of these factors, aorta narrowing on CT may be a simple method for estimation of time of death, perhaps in combination with multiple approaches.[7,8]

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